**Must-Knows: Unit 7 (Cell Signaling)**

Ms. Ottolini, AP Biology

**Test Format:** 17 multiple choice questions, 1 short answer question

***Directions:*** *To prepare for your upcoming test, please answer the following questions thoroughly and accurately on your answer sheet in the column titled “Your Answer Before Checking the Answer Key.” Then, check the answer key (posted on Ms. Ottolini’s wiki page). Finally, record any additions / changes to your answer in the column titled “Changes / Additions to Your Answer After Checking the Answer Key”*

**Topic #1: The Basics of Cell Signaling**

**Learning Target #1:** You will be able to describe what happens in each of the three main steps of cell signaling—reception, transduction, and response—and provide examples of each.

**Learning Target #2:** You will be able to compare/contrast cell signaling between cells that are connected, cells that are separated by a small distance, and cells that are separated by a large distance.

**Learning Target #3:** You will be able to compare the purpose of cell signaling in unicellular vs. multicellular organisms and provide examples of each.

**Learning Target #4:** You will be able to predict the effects of changes in cell signaling pathways.

**Topic #2: Mitosis**

1. A small, nonpolar signal molecule is sent to a target cell. What type of receptor is used (intracellular vs. plasma membrane) and what type of response occurs (cytoplasmic vs. nuclear)? Explain your answers.

An intracellular receptor is used because a small, nonpolar signal molecule can pass through the cell membrane. Intracellular receptors can double as transcription factors, proteins that can turn on genes in the nucleus (i.e. a nuclear response).

1. A large, polar signal molecule is sent to a target cell. What type of receptor is used (intracellular vs. plasma membrane) and what type of response occurs (cytoplasmic vs. nuclear)? Explain your answers.

A plasma membrane receptor is used because a large, polar signal molecule cannot pass through the cell membrane. Plasma membrane receptors often activate a signal transduction pathway (i.e. with second messengers and phosphorylation cascades) that ends with the activation of the target enzyme in the cytoplasm (i.e. a cytoplasmic response).

1. Provide an example of cell signaling by direct contact in either animals or plants. What are the pros and cons of using this method of signaling?

In plants, plasmodesmata (holes in the cell walls) in adjacent cell walls can allow the passage of signals from the cytoplasm of one cell to the cytoplasm of another.

Pros = This type of cell signaling is FAST.

Cons = Only cells that are physically connected to one another can send signals to one another.

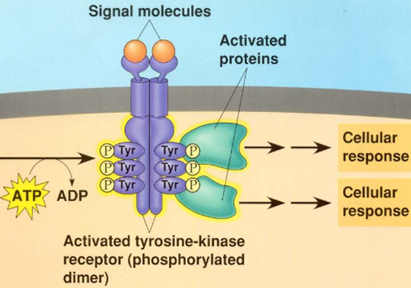
1. The endocrine system is used for signaling across long distances. What are the pros and cons of using this method of cell signaling?

Pros = Since the signal molecules (hormones) are secreted into the bloodstream, they can travel to multiple different target cells/tissues/organs and cause multiple responses.

Cons = This type of cell signaling, is SLOW.

1. In class, we learned about the epinephrine signaling pathway involved in the fight or flight response. If the second messenger molecule cyclic AMP (cAMP) cannot be created during the transduction step of this pathway, what will be the final effect on the signaling pathway?

If cyclic AMP cannot be created, protein kinases and eventually the target enzyme (phosphorylase) cannot be activated. This results in a smaller response or no response at all.

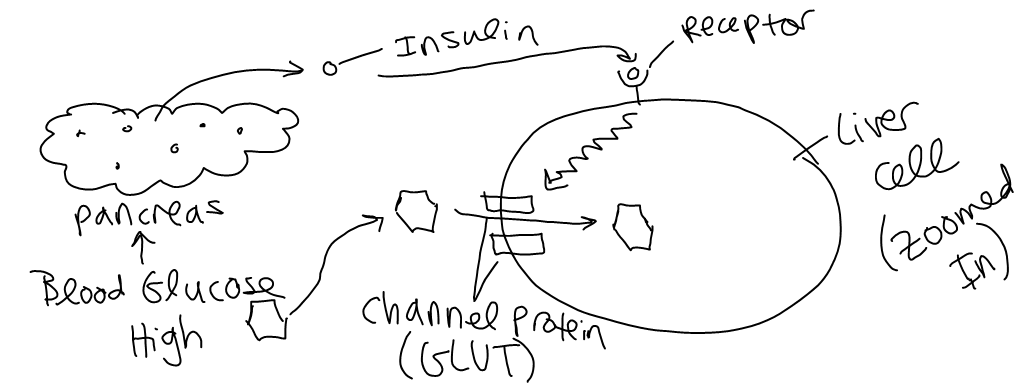


1. If ATP is not present in the cell pictured to the right, what would be the most immediate effect on the receptor tyrosine kinase pathway?

The tyrosine molecules on the receptors will be unable to remove a phosphate group from ATP and use it to activate other proteins in the pathway and ultimately produce a response.

1. Explain how insulin is used in the pathway pictured below to lower blood glucose.

In response to high blood glucose, the pancreas secretes insulin, which travels through the bloodstream and binds to a receptor located on the surface of a liver cell. The receptor activates a signal transduction pathway, which ultimately results in the insertion of a glucose channel protein (GLUT) in the liver cell membrane. The glucose channel allows glucose to be taken into the liver cell and stored as glycogen, reducing blood glucose levels.



**Topic #2: The Nervous System**

**Learning Target #5:** You will be able to identify the main parts of the human nervous system.

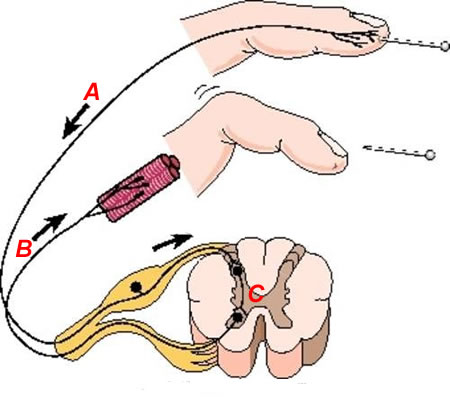
**Learning Target #6:** You will be able to outline the steps involved in a reflex arc.

**Learning Target #7:** You will be able to identify the parts of a neuron and their functions.

**Learning Target #8:** You will be able to describe the movement of a signal (action potential) down the length of a single neuron.

**Learning Target #9:** You will be able to describe the movement of a signal from one neuron to another.

**Topic #4: Regulation of the Cell Cycle**

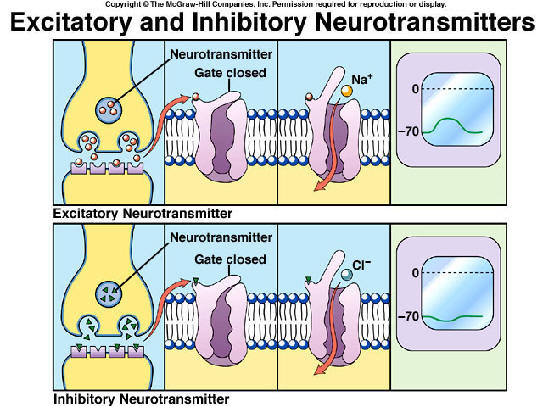
1. Identify the neurons involved in the polysynaptic reflex arc pictured to the right and explain how they interact to produce a response to the stimulus.

A stimulus (ex: a pinprick on a finger) stimulates a sensory neuron, which travels to the spinal cord and synapses on (connects with) an interneuron. The interneuron then synapses on a motor neuron, which travels back out to the hand and causes muscle contraction within the finger to pull it away from the stimulus.

1. How is an excitatory neurotransmitter different from an inhibitory neurotransmitter?

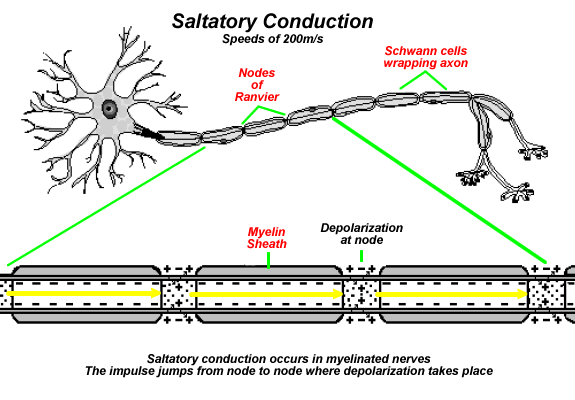
An excitatory neurotransmitter promotes an action potential in the postsynaptic neuron. Excitatory neurotransmitters usually bind to ligand-gated Na+ channels on the dendrite membrane of the post-synaptic neuron. When these channels open, Na+ rushes into the cell. Once enough Na+ has entered the cell to raise the membrane potential to -55 mV (threshold), the voltage-gated Na+ channels will open and begin the depolarization stage of the action potential.

An inhibitory neurotransmitter prevents an action potential in the postsynaptic neuron. Inhibitory neurotransmitters either cause the opening of channels on the post-synaptic neuron that let negatively charged chloride ions (Cl-) into the cell or positively charged potassium ions (K+) out of the cell. Either way, the membrane potential decreases below the resting potential (-70 mV) rather than increasing to threshold (-55 mV), the voltage at which an action potential begins.



1. What is the role of Schwann cells in nerve signaling?

Schwann cells made of fatty myelin sheath surround the axon and cause the action potential to jump between empty spaces along the axon (i.e. the Nodes of Ranvier). This improves the speed of signal transmission down the length of the axon. The process of the signal “jumping” from node to node is called saltatory conduction.



1. Which ion channels are involved in the depolarization phase of the action potential? How does the opening of these channels affect the membrane potential inside the neuron?

Voltage-gated sodium channels open during depolarization and allow Na+ to rush into the neuron from a higher concentration outside the cell to a lower concentration inside the cell. Positively charged Na+ coming into the cell raises the membrane potential.

1. Which ion channels are involved in the repolarization phase of the action potential? How does the opening of these channels affect the membrane potential inside the neuron?

Voltage-gated potassium channels open during repolarization and allow K+ to rush out of the neuron from a higher concentration inside the cell to a lower concentration outside the cell. Positively charged K+ leaving the cell lowers the membrane potential.

1. How do nerve cells reach threshold potential (-55 mV)? What happens when a nerve cell reaches threshold?

A stimulus (ex: the binding of a neurotransmitter) typically opens ligand-gated Na+ channels on the dendrite membrane, allowing positively charged Na+ to rush into the cell, raising the membrane potential to its threshold value (-55 mV). Once enough positively charged Na+ comes into the cell to raise the membrane potential to threshold, the positive charge opens voltage-gated Na+ channels on the axon, causing more Na+ to rush into the cell and begin the depolarization phase of the action potential.

1. List the steps involved in the transmission of a signal across a synapse. Start from the wave of depolarization (the action potential) reaching the presynaptic neuron’s axon terminal. End with the postsynaptic neuron reaching threshold potential.

-Depolarization (due to Na+) rushing into the axon reaches the presynaptic neuron’s axon terminal and causes voltage-gated Ca2+ channels to open.

- Ca2+ rushes into the cell and causes vesicles containing neurotransmitter to fuse with the axon terminal membrane and release the neurotransmitter into the synapse.

-Neurotransmitter particles diffuse across the synapse and bind to ligand-gated Na+ channels on the postsynaptic neuron’s dendrite membrane.

-The ligand-gated Na+ channels open, allowing Na+ to rush into the cell, eventually raising the membrane potential to threshold (-55 mv).

**Topic #3: The Endocrine System**

**Learning Target #10:** You will be able to describe how the secretion of a single hormone from a gland can result in multiple responses in the body.

**Learning Target #11:** You will be able to compare / contrast the different types of hormone molecules.

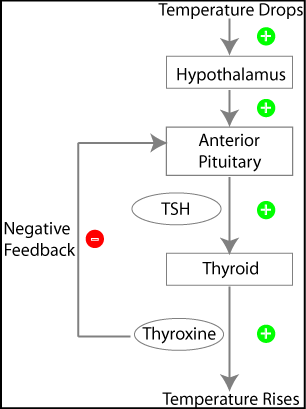
**Learning Target #12:** You will be able to explain how various hormones are used in positive and negative feedback loops.

1. When the concentration of solutes in the blood (blood osmolarity) is high, the pituitary gland releases antidiuretic hormone (ADH). ADH stimulates the kidneys to reabsorb water in order to increase blood volume and decrease blood osmolarity. When the kidneys reabsorb water, this causes the urine to be extremely concentrated (i.e. have a low water content).

Ms. Ottolini overhydrates in preparation for a big race (yeah right, she is far too lazy for this!). How will her body respond to this massive intake of water, which results in a high blood volume?

A high blood volume and low blood osmolarity inhibits secretion of ADH from the pituitary. This prevents the kidneys from reabsorbing water, and results in lowered blood volume / higher blood osmolarity and more dilute urine (i.e. with a high water content).

1. The hypothalamus and pituitary release hormones to stimulate the thyroid gland to create thyroxine, a hormone that speeds up metabolism. How does the production of thyroxine affect the hypothalamus and pituitary? Is this an example of positive or negative feedback? Why?

Initially, the hypothalamus releases hormones to stimulate the anterior pituitary to release TSH, which stimulates the thyroid gland to produce thyroxine. Thyroxine inhibits production of both hypothalamic hormones and and TSH, to limit the production of additional thyroxine. This is an example of negative feedback because the response (i.e. the inhibition of hypothalamic hormone and TSH production) decreases the stimulus (i.e. the production of thyroxine).

1. Let’s say the hormone oxytocin causes uterine contractions during mammalian labor. The uterine contractions, in turn, cause the release of more oxytocin, which causes even stronger contractions. Is this an example of positive or negative feedback? Why?

This is an example of positive feedback because the response (i.e. the uterine contractions) increases the stimulus (i.e. the release of oxytocin).

1. When your blood calcium levels are too high, the hormone calcitonin causes the absorption of excess calcium into the bones, lowering the level of calcium in the blood. Is this an example of positive or negative feedback? Why?

This is an example of negative feedback because the response (i.e. release of calcitonin) decreases the stimulus (i.e. high blood calcium).